## Exam #2 Practice Problems – Chapter 4

### *Solubility Rules*

Which combinations will result in *fully soluble* (aq) final solutions?

a) $K_3PO_4$ (aq) + $Al(NO_3)_3$ (aq) → $3\,KNO_3(aq)$ (soluble) + $AlPO_4(s)$ (precipitate)

b) $BeI_2$ (aq) + $Cu_2SO_4$ (aq) → $BeSO_4(aq) + CuI(aq)$

c) $Ni(NO_3)_3$ (aq) + 3KBr (aq) → $NiBr_3(aq) + 3\,KNO_3(aq)$

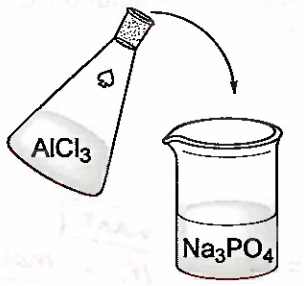
d) cobalt (III) bromide + potassium sulfide → $2\,CoBr_3(aq) + 3\,K_2S(aq) \rightarrow Co_2S_3(s) + 6\,KBr(aq)$ (precipitate)

e) barium nitrate + ammonium phosphate → $3\,Ba(NO_3)_2(aq) + 2\,(NH_4)_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + 6\,NH_4NO_3(aq)$ (precipitate)

### *Types of Reactions*

Classify the following reactions and predict the product(s), if any, formed from a balanced chemical equation:

a)




precipitate

$AlCl_3(aq) + Na_3PO_4(aq) \rightarrow AlPO_4(s) + 3\,NaCl(aq)$

Reaction type: precipitation

Product(s) Formed: $AlPO_4$ & NaCl ($Na^+$ & $Cl^-$ in soln)

b) $HNO_3$ combined with potassium hydroxide

($HNO_3$: strong acid; KOH: strong base)

$HNO_3(aq) + KOH \rightarrow KNO_3(aq) + H_2O(l)$

($KNO_3$: "salt"; $H_2O$: water)

Reaction type: neutralization / acid-base

Product(s) Formed: $KNO_3$ ($K^+$ & $NO_3^-$ in soln) & $H_2O$

## *Concentration*

1) Cask **A** contains an alcohol solution with a concentration of 18.0 M. If 6.0 L is taken out (**B**) and 6.0 L of water is added to it (cask **C**), then the concentration drops to 15.0 M. a) What is the Molarity of cask **B**? b) What is the original volume in cask **A**?

* Remember molarity doesn't change just b/c you change location (i.e. no Δ in moles relative to volume)

Know

$M_c = 18.0\,M$

$M_c = 18.0\,M$
$V_c = 6.0\,L$

$V_d = 6.0\,L + 6.0\,L = 12.0\,L$
$M_d = 15.0\,M$

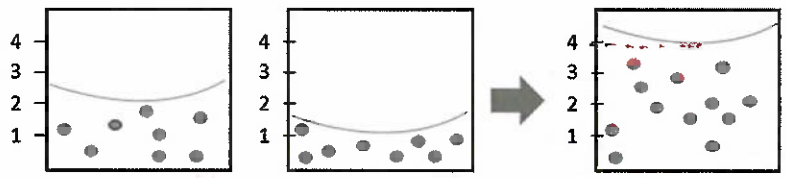
Dilution (B→C): $M_c V_c = M_d V_d$ (want $V_c$)

Plan $V_c = \frac{M_d V_d}{M_c}$

$V_c = \frac{(15.0\,M)(12.0\,L)}{(18.0\,M)}$

$V_c = 10.0\,L$ must have been in cask A

2) Some volume of solution A and solution B be were combined to form solution C. Assuming these are all liter flasks, what is the concentration of solution C?




moles = counting!

Know: moles = 12, V = 4.0 L

want $M = \frac{\text{moles solute}}{\text{L sol'n}}$

$M = \frac{12\,mol}{4.0\,L} = 3.0\,M$

3) A person suffering from hypotremia has a sodium ion concentration in the blood of 0.118 M and a total blood volume of 4.6 L. What mass of sodium chloride (saline solution) would need to be added to the blood to bring the sodium ion concentration up to 0.138 M, assuming no change in blood volume?

want: mass (g) NaCl added

Know
$[Na^+]_{initial} = 0.118\,M$
$V = 4.6\,L$

final for obtaining: ?
$[Na^+] = 0.138\,M$
$V = 4.6\,L$

Plan
① Det. moles initial ⇒ V × M = mol
② Det. moles final ⇒ V × M = mol
③ Det. moles added ⇒ moles final − moles initial
④ mol $Na^+$ → (subscripts, chem. formulas) → mol NaCl → (Mass) → g NaCl

$M_{NaCl} = 58.44\,g/mol$

Solve
① $4.6\,L \times \frac{0.118\,mol\,Na^+}{L} = 0.54$ moles initial $Na^+$
② $4.6\,L \times \frac{0.138\,mol\,Na^+}{L} = 0.63$ moles final $Na^+$
③ $0.63\,mol\,Na^+_{final} - 0.54\,mol\,Na^+_{initial} = 0.09\,mol\,Na^+$ to be added
④ $0.09\,mol\,Na^+ \times \frac{1\,mol\,NaCl}{1\,mol\,Na^+} \times \frac{58.44\,g\,NaCl}{1\,mol\,NaCl} = 5\,g\,NaCl$ (1 sig. fig.)

(saline sol'n) need stobeadd

4) The quantity of $Cl^-$ in a municipal water supply is determined by titrating the sample with $Ag^+$. A precipitation takes place and the end point is determined by a color change of an indicator. How many grams of chloride ion are in a sample of the water if 20.2 mL of 0.100 M $Ag^+$ is needed to react with all the chloride in the sample? If the sample has a mass of 10.0 g, what percentage of $Cl^-$ does it contain?

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ ← precipitate

$M_{Cl^-} = 35.452$ g/mol *since we don't weigh each $Cl^-$ ≈ Cl in mass

Know: $Ag^+$, $[Ag^+] = 0.100\,M$, $V = 20.2\,mL$

Sample: $m = 10.0\,g$

Want: ① $Cl^-$ g ? ② % $Cl^-$ in sample?

Plan: ① $V_{Ag^+} \xrightarrow{M_{Ag^+}} mol\ Ag^+ \xrightarrow[eq'n]{molar\ ratio} mol\ Cl^- \xrightarrow{M} g\ Cl$

② % mass = $\frac{g\ Cl^-}{g\ sample} \times 100$

Solve

$$20.2\,mL\ Ag^+ \times \frac{1\,L}{1000\,mL} \times \frac{0.100\,mol\ Ag^+}{L\ sol'n} \times \frac{1\,mol\ Cl^-}{1\,mol\ Ag^+} \times \frac{35.4527\,g\ Cl^-}{1\,mol\ Cl^-} = 7.17\times10^{-2}\,g\ Cl^-$$

$$\%\ Cl^- = \frac{7.17\times10^{-2}\,g\ Cl^-}{10.0\,g\ sample} \times 100 = 0.717\%\ Cl^-\ in\ the\ sample$$

5) Your friend has heartburn and takes Tums® ($CaCO_3$). A reaction occurs when it reacts with their stomach acid (HCl).

A. What *type of reaction* is this? acid-base / neutralization

B. What is the *balanced molecular equation* of the reaction.

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

* Recall $H_2CO_3$ is NOT stable & ∴ decomposes to these

C. What is the *complete ionic equation*?

$CaCO_3(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq) + H_2O(l) + CO_2(g)$

D. Which, if any, ions are *spectator ions*?

$Cl^-$

C. What is the *net ionic equation*?

$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

## Assorted Questions

6) Which one of the following is not true concerning 2.00 L of 0.100 M solution of $Ca_3(PO_4)_2$?

A) This solution contains 0.200 mol of $Ca_3(PO_4)_2$.
B) This solution contains 0.800 mol of oxygen atoms.
C) 1.00 L of this solution is required to furnish 0.300 mol of $Ca^{2+}$ ions.
D) There are $6.02 \times 10^{22}$ phosphorus atoms in 500.0 mL of this solution.
E) This solution contains $6.67 \times 10^{-2}$ mol of $Ca^{2+}$.

7) A 0.200 M $K_2SO_4$ solution is produced by _____.

A) dilution of 250.0 mL of 1.00 M $K_2SO_4$ to 1.00 L
B) dissolving 43.6 g of $K_2SO_4$ in water and diluting to a total volume of 250.0 mL
C) diluting 20.0 mL of 5.00 M $K_2SO_4$ solution to 500.0 mL
D) dissolving 20.2 g of $K_2SO_4$ in water and diluting to 250.0 mL, then diluting 25.0 mL of this solution to a total volume of 500.0 mL
E) dilution of 1.00 mL of 250 M $K_2SO_3$ to 1.00 L

8) Which solution has the same number of moles of NaOH as 50.00 mL of 0.100*M* solution of NaOH?

A) 20.00 mL of 0.200*M* solution of NaOH
B) 25.00 mL of 0.175*M* solution of NaOH
C) 30.00 mL of 0.145*M* solution of NaOH
D) 50.00 mL of 0.125*M* solution of NaOH
E) 100.00 mL of 0.0500*M* solution of NaOH

9) What are the respective concentrations (M) of $Fe^{3+}$ and $I^-$ afforded by dissolving 0.200 mol $FeI_3$ in water and diluting to 725 mL?

A) 0.276 and 0.828
B) 0.828 and 0.276
C) 0.276 and 0.276
D) 0.145 and 0.435
E) 0.145 and 0.0483

10) A 0.100 M solution of _____ will contain the highest concentration of potassium ions.

A) potassium phosphate
B) potassium hydrogen carbonate
C) potassium hypochlorite
D) potassium iodide
E) potassium oxide

11) What volume (mL) of a concentrated solution of magnesium chloride (9.00 M) must be diluted to 350. mL to make a 2.75 M solution of magnesium chloride?

A) 2.75 B) 50.0 C) 45.0 D) 107 E) 350

12) What mass (g) of $CaF_2$ is formed when 47.8 mL of 0.334 M NaF is treated with an excess of aqueous calcium nitrate?

A) 1.25 B) 0.472 C) 2.49 D) 0.943 E) 0.623

*See key pgs for work *

13) What volume (L) of 0.250 M $HNO_3$ is required to neutralize a solution prepared by dissolving 17.5 g of NaOH in 350 mL of water?

A) 50.0 B) 0.44 C) 1.75 D) 0.070 E) $1.75 \times 10^{-3}$

14) An aliquot (28.7 mL) of a KOH solution required 31.3 mL of 0.118 M HCl for neutralization. What mass (g) of KOH was in the original sample?

A) 1.64 B) 7.28 C) 0.173 D) 0.207 E) 0.414

15) Which of the following would require the largest volume of 0.100 M sodium hydroxide solution for neutralization?

A) 10.0 mL of 0.0500 M phosphoric acid
B) 20.0 mL of 0.0500 M nitric acid
C) 5.0 mL of 0.0100 M sulfuric acid
D) 15.0 mL of 0.0500 M hydrobromic acid
E) 10.0 mL of 0.0500 M perchloric acid

16) A 13.8 mL aliquot of 0.176 M $H_3PO_4$ (aq) is to be titrated with 0.110 M NaOH (aq). What volume (mL) of base will it take to reach the equivalence point?

A) 7.29 B) 22.1 C) 199 D) 66.2 E) 20.9

17) Which of the following are strong electrolytes?

**HCl** (↳ strong acid ✓) **$HC_2H_3O_2NH_3$** (could be weak acid buffer; ↳ molecular ✗) **KCl** (↳ soluble salt ✓)

A) HCl, KCl B) HCl, $NH_3$, KCl C) HCl, $HC_2H_3O_2$, $NH_3$, KCl
D) HCl, $HC_2H_3O_2$, KCl E) $HC_2H_3O_2$, KCl

18) What are the spectator ions in the reaction between $Mg(OH)_2$ (aq) and HCl (aq)?

$Mg(OH)_2(aq) + 2HCl(aq) \rightarrow 2H_2O(l) + MgCl_2(aq)$ ⇒ $Mg^{2+}_{(aq)} + 2OH^-_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)}$

spectator ions: $Mg^{2+}_{(aq)} + 2Cl^-_{(aq)}$ + $2H_2O(l)$

A) $Mg^{+2}$ and $H^+$ B) $H^+$ and $OH^-$ C) $Mg^{+2}$ and $Cl^-$
D) $H^+$ and $Cl^-$ E) $OH^-$ only

19) Which of the following are strong acids? **HI** ✓ **$HNO_3$** ✓ **HF** (↳ weak) **HBr** ✓

A) HF, HBr B) HI, $HNO_3$, HF, HBr C) HI, HF, HBr
D) $HNO_3$, HF, HBr E) HI, $HNO_3$, HBr

20) Which hydroxides are strong bases? **$Sr(OH)_2$** ✓ **KOH** ✓ **NaOH** ✓ **$Ba(OH)_2$** ✓ all

A) KOH, $Ba(OH)_2$ B) KOH, NaOH C) KOH, NaOH, $Ba(OH)_2$
D) $Sr(OH)_2$, KOH, NaOH, $Ba(OH)_2$ E) None of these is a strong base.

21) The molarity (M) of an aqueous solution containing 52.5 g of sucrose ($C_{12}H_{22}O_{11}$) in 35.5 mL of solution is _____.

$M = 342.2965$ g/mol

A) 5.46 B) 1.48 C) 0.104 D) 4.32 E) 1.85

want $M = \frac{\text{moles sucrose}}{\text{L soln}}$

$52.5\text{ g sucrose} \times \frac{\text{mol sucrose}}{342.2965\text{ g sucrose}} = 0.153\text{ mol sucrose}$

$35.5\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.0355\text{ L}$

$M = \frac{0.153\text{ mol sucrose}}{0.0355\text{ L}} = 4.32\text{ M sucrose}$

7) ~~A~~ $M_d = \frac{M_c V_c}{V_d} = \frac{(1.00\,M)(250.0\,mL)}{(1000\,mL)} = 0.250\,M \neq 0.2\,M$

(1000 mL from 1.00 L)

~~B~~ $43.6\,g \times \frac{mol}{174.259\,g} = \frac{.250\,mol\ K_2SO_4}{1} \times \frac{1}{250.0\,mL} \times \frac{1000\,mL}{1\,L} = 1.00\,M \neq 0.2$

($\frac{mol}{174.259\,g}$ = $M_{K_2SO_4}$)

C) $M_d = \frac{M_c V_c}{V_d} = \frac{(5.00\,M)(20.0\,mL)}{(500.0\,mL)} = \boxed{0.200\,M}$ ✓

~~D~~ $20.2\,g \times \frac{mol}{174.259\,g} \times \frac{1}{.250\,L} = .464\,M \neq 0.200\,M$ &

$M_d = \frac{M_c V_c}{V_d} = \frac{(0.464\,M)(25.0\,mL)}{(500.0\,mL)} = 0.02\,M$ ✱ .200 M

E) $M_d = \frac{M_c V_c}{V_d} = \frac{(250\,M)(1.00\,mL)}{(1000\,mL)} = 0.25\,M \neq 0.200\,M$

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8) goal: $50.00\,mL \times \frac{0.100\,mol\ NaOH}{L\ sol'n} \times \frac{1\,L}{1000\,mL} = 5.00 \times 10^{-3}\ moles\ NaOH$

~~A~~ $\frac{0.200\,mol\ NaOH}{L} \times 20.00\,mL \times \frac{1\,L}{1000\,mL} = 4.00 \times 10^{-3}\ moles\ NaOH$ X

~~B~~ $\frac{0.175\,mol\ NaOH}{L} \times 25.00\,mL \times \frac{1\,L}{1000\,mL} = 4.38 \times 10^{-3}\ moles\ NaOH$ X

~~C~~ $\frac{0.145\,mol\ NaOH}{L} \times 30.00\,mL \times \frac{1\,L}{1000\,mL} = 4.35 \times 10^{-3}\ moles\ NaOH$ X

~~D~~ $\frac{0.125\,mol\ NaOH}{L} \times 50.00\,mL \times \frac{1\,L}{1000\,mL} = 6.25 \times 10^{-3}\ moles\ NaOH$ X

E) $\frac{0.0500\,mol\ NaOH}{L} \times 100.00\,mL \times \frac{1\,L}{1000\,mL} = 5.00 \times 10^{-3}\ moles\ NaOH$ ✓

9) $[Fe^{3+}]$ ? $[I^-]$ ?

$\frac{0.200\,mol\ FeI_3}{725\,mL} \times \frac{1000\,mL}{1\,L} = 0.276\,M\ FeI_3$ (1 Fe, 3 I)

$[I^-] = 0.276\,M \times 3 = 0.828\,M$

$[Fe^{3+}] = 0.276\,M \times 1 = 0.276\,M$

A

10) (A) $K_3PO_4$ (3)

B) $KHCO_3$

C) $KClO$

D) $KI$

E) $K_2O$

0.100 M soln's  want: highest $[K^+]$

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11) want: $V_c = ?$ mL $= \frac{M_d V_d}{M_c}$ know $= \frac{(2.75\,M)(350.\,mL)}{(9.00\,M)} = 107\,mL$ **D**

$M_c V_c = M_d V_d$

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12) want: $m_{CaF_2}$ in g

know: $2\,NaF(aq) + Ca(NO_3)_2(aq) \rightarrow 2\,NaNO_3(aq) + CaF_2(s)$

limiting ← excess

$\mathcal{M}_{CaF_2} = 78.07\,g/mol$

Plan: mL $_{NaF}$ $\xrightarrow{M_{NaF}}$ mol NaF $\xrightarrow[\text{coefficients}]{\text{molar ratio}}$ mol $CaF_2$ $\xrightarrow{\mathcal{M}_{CaF_2}}$ g $CaF_2$

Solve: $47.8\,mL \times \frac{0.334\,mol\,NaF}{L} \times \frac{1\,L}{1000\,mL} \times \frac{1\,mol\,CaF_2}{2\,mol\,NaF} \times \frac{78.07\,g\,CaF_2}{mol\,CaF_2} =$

**E** 0.623 g $CaF_2$

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13) want: $V_{HNO_3}$ in L

know: $NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$

$m = 17.5\,g$, $V = 350\,mL$, $M = 0.250$

Plan: $m_{NaOH} \xrightarrow{\mathcal{M}_{NaOH} = 40.00\,g/mol}$ mol NaOH $\xrightarrow[\text{coefficients}]{\text{molar ratio}}$ mol $HNO_3$ $\xrightarrow{M_{HNO_3}}$ $V_{HNO_3}$

Solve: $17.5\,g\,NaOH \times \frac{mol\,NaOH}{40.00\,g\,NaOH} \times \frac{1\,mol\,HNO_3}{1\,mol\,NaOH} \times \frac{L}{0.250\,mol\,HNO_3} = 1.75\,L_{HNO_3}$ **C**

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14) want: g KOH

know: $KOH(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l)$

$V = 20.7\,mL$, $V = 31.3\,mL$, $M = 0.118\,M$

$\mathcal{M}_{KOH} = 56.1056\,g/mol$

Plan: $V_{HCl} \xrightarrow{M_{HCl}}$ mol HCl $\xrightarrow[\text{coefficients}]{\text{molar ratio}}$ mol KOH $\xrightarrow{\mathcal{M}_{KOH}}$ g KOH

Solve: $31.3\,mL \times \frac{0.118\,mol\,HCl}{L} \times \frac{1\,L}{1000\,mL} \times \frac{1\,mol\,KOH}{1\,mol\,HCl} \times \frac{56.1056\,g\,KOH}{1\,mol\,KOH} = 0.207\,g\,KOH$

**D**

15) want largest V to neutralize w/ 0.100 M NaOH ⇒ the one w/ the most moles

A) $\square H_3PO_{4(aq)} + \boxed{3} NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + 3H_2O_{(l)}$

$$10.0\,mL \times \frac{0.0500\,mol\,H_3PO_4}{L\ sol'n} \times \frac{1\,L}{1000\,mL} \times \frac{3\,mol\,NaOH}{1\,mol\,H_3PO_4} = 1.50\times10^{-3}\ moles\ NaOH$$

will require largest V b/c most mol

B) $\square HNO_{3(aq)} + \square NaOH_{(aq)} \rightarrow NaNO_{3(aq)} + H_2O_{(l)}$

$$20.0\,mL \times \frac{0.0500\,mol\,HNO_3}{L} \times \frac{1\,L}{1000\,mL} \times \frac{1\,mol\,NaOH}{1\,mol\,HNO_3} = 1.00\times10^{-3}\ moles\ NaOH$$

C) $\square H_2SO_{4(aq)} + \boxed{2} NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$

$$5.0\,mL \times \frac{0.0100\,mol\,H_2SO_4}{L} \times \frac{1\,L}{1000\,mL} \times \frac{2\,mol\,NaOH}{1\,mol\,H_2SO_4} = 1.0\times10^{-4}\ moles\ NaOH$$

D) $\square HBr_{(aq)} + \square NaOH_{(aq)} \rightarrow NaBr_{(aq)} + H_2O_{(l)}$

$$15.0\,mL \times \frac{0.0500\,mol\,HBr}{L} \times \frac{1\,L}{1000\,mL} \times \frac{1\,mol\,NaOH}{1\,mol\,HBr} = 7.50\times10^{-4}\ moles\ NaOH$$

E) $\square HClO_{4(aq)} + \square NaOH_{(aq)} \rightarrow NaClO_{4(aq)} + H_2O_{(l)}$

$$10.0\,mL \times \frac{0.0500\,mol\,HClO_4}{L} \times \frac{1\,L}{1000\,mL} \times \frac{1\,mol\,NaOH}{1\,mol\,HClO_4} = 5.00\times10^{-4}\ moles\ NaOH$$

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16) want: mL NaOH to equivalence point

Know: $H_3PO_{4(aq)} + 3NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + 3H_2O$

$V = 13.8\,mL$ $M = 0.110\,M$

$M = 0.176\,M$

Plan: $V_{H_3PO_4} \xrightarrow{M_{H_3PO_4}} mol\ H_3PO_4 \xrightarrow[\text{coefficients}]{\text{molar ratio}} mol\ NaOH \xrightarrow{M_{NaOH}} V_{NaOH}$

Solve

$$13.8\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.176\,mol\,H_3PO_4}{L} \times \frac{3\,mol\,NaOH}{1\,mol\,H_3PO_4} \times \frac{L}{0.110\,mol\,NaOH} \times \frac{1000\,mL}{1\,L} = 66.2\,mL\,NaOH$$

D